

■ ECON 252 Financial Markets -

03 Technology and Invention in Finance

Lecture Briefing

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ECON 252: Financial Markets

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Overview:

Technology and innovation underlie finance. In order to manage risks successfully, particularly long-term, we must pool large amounts of risk among many, diverse people and overcome barriers such as moral hazard and erroneous framing. Inventions such as insurance contracts and social security, and information technology all the way from such simple things as paper, and the postal service to modern computers have helped to manage risks and to encourage financial systems to address issues pertaining to risk. The tax and welfare system is one of the most important risk management systems.

Reading assignment:

Robert Shiller, *The New Financial Order*, Introduction

Class lecture:

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Professor Robert Shiller: I thought I would just remember a couple of highlights from the first two lectures to consolidate what we said then. In the first lecture, I talked about a lot of things, but one theme that comes to my mind is the theme of the moral purpose and mission of the finance community. We talked about the sense that, I think, young people have a sort of prejudice against the field and they think that finance is a field that you go into if you really value money rather than people. I want to reiterate again that that's not the way I view the field at all. I was just yesterday--I gave a talk in Montreal at the Caisse de Dépôt, et Placement du Québec, which is the big wealth management fund for the Province of Quebec. I met a lot of people there and I never once got the idea that anyone there was evil or grasping. I think they have a moral purpose, which is to preserve the livelihoods of the people of the Province of Quebec. You get a very different view of things when you meet the people. I think our entertainment industry likes to make movies about people in finance, but they are inevitably portrayed as evil and I don't know why that is. I don't think there has ever been a major motion picture about a financial person who ended up a philanthropist. Why is that? I just don't--people don't like--people would rather hate--I don't know why it's something--it wouldn't be a good movie theme, would it?

Anyway, you have to overcome these--you have to think that if you go into the field you would probably--if you're successful--you would probably end up as a philanthropist; but no movie will be made about your life and you may encounter hostility the whole way. It's especially true right now with the subprime crisis. People are blaming the financial community for our troubles now. It is true that we're seeing some people thrown out of their houses, in some cases, because of some rather questionable financial practices that got people into mortgages that they shouldn't have gotten into. But overall, I think that the people in this field are good people.

In the last lecture, I talked about--In the second lecture, I talked about the pooling of risks and the basic theme of that lecture was that we now have a mathematical theory, probability theory. When you look at this theory, you realize that it suggests a very important technology for improving human welfare and that is: by spreading risks. The economy, and technology, and the weather, and all sorts of factors create risks. But, the real technology is--the technology that works to eliminate risks is to spread them out, to pool them, to share them among many different people. So, the idea that theorists suggest--and it may be unreachable--but the perfect financial system would have all of our risks pooled completely. That is, nobody suffers alone. If anything happens to me in my livelihood, then it's spread out over everybody and everybody means the whole world. Whatever happens to me, when it's spread out over six billion plus people, it ends up divided by six billion and it becomes unobservable. It becomes so small that it's meaningless and that's the ideal. That's what, in principle, we can do and what I think is

the most important concept in finance--this concept of risk pooling. We live in a world where people suffer all kinds of misfortunes. Of course, we can try to get rid of these misfortunes. We can do research on disease prevention and weather modification and global warming. We can do research on all these things, but there's another technology, which is extremely important. That is, even leaving the risks as they are and just sharing them better. So, I'll be talking more about this.

The problem is that while the principle of risk-sharing is very simple and obvious the practice requires technology. It's just like you could say some of the principles of mechanics are very obvious, but to make an engine that operates in terms of those principles is not obvious.

What I want to talk today about is what I call technology in finance. I'll present my view of the situation, but maybe it's a rather idiosyncratic view that I have. But, I think--It's not so much idiosyncratic, but it's a different emphasis that I put forth. What I want to talk-- There are really three themes to today's lecture: a risk theme, a framing theme, and an invention theme. I want to go over the history of risk management and through these three themes.

The first one is, I might say, a long-term risk theme. Let me go over these three themes. The long-term risks are dominant in our lives. By that, I mean that everyone's life is a sequence of shocks that accumulate over your life. I'm talking about economic shocks. When you start out young--We're unequal at birth, of course, because of our parents and the advantages we have, but relatively equal at a young age. As each year goes by, you accumulate economic shocks, shocks to your human capital, shocks to what you own as you get older. You start--Your human capital is your ability to do things and your knowledge, which is what you have to sell in the marketplace. As you get older, your human capital evolves and it has its ups and downs as you age and you start switching from human capital to other forms of capital. In other words, you start saving and you own stocks and bonds, and real estate, and other things. Each of these suffers a sequence of shocks that cumulate over your lifetime, so inequality gets worse and worse as people age. It is at its worst after retirement when you are no longer--you've exhausted your human capital and you're living off of all the accumulated physical capital. That's the life cycle story.

There's great inequality among the elderly and that's a problem. Some of them are living very badly and others are living with great comfort. That's what finance is about. It's really about people. We don't care at all about corporations--we should make that clear--except as they contribute to individual welfare. I don't care what happens to Citigroup or IBM, except for the fact that there are all those stockholders out there and they're of all different situations. Some of them are absolutely dependent on their holding of these stocks. That's what we have to think about and it's a long-term problem.

The problem with long-term risks, also, is that anything that we do to mitigate these risks creates moral hazard. That's another fundamental theme of finance. What is moral hazard? That's a term that first entered the English language sometime in the mid-nineteenth century, but of course the concept goes earlier. Moral hazard occurs when a risk management institution incentivizes you to do bad behavior--to show bad behavior. The classic example of moral hazard is with fire insurance. I get fire insurance on my house and so I behave badly: I deliberately burn the house down to collect on my insurance. That's moral hazard; but it's not unique to that, it's all over the place. When

you manage risks, you create moral hazard. That's why we need invention and theory in finance to minimize that.

The second theme for this lecture is about framing. By that I mean psychological framing, and there are many psychologists who talk about this, but notably Daniel Kahneman and Amos Tversky. "Psychological framing" means the tendency for people to view things in a distorted way depending on how they're presented. If I present things in one frame, then you would react one way. If I present the same thing in another context or background or environment, then you react very differently. I will expand on this in a minute.

The third theme is the invention theme of this lecture. That is--I mentioned this before, but I want to expand on it in this lecture--that the history of finance is the history of invention just as much as it is in other fields, notably engineering. The idea that I want to develop is that the history of finance is a history of discrete inventions. Non-obvious ideas were conceived of to solve these problems of long-term risks and to get around the psychological barriers imposed by framing biases and psychological biases, in order to allow people to actually manage the risk and to get around moral hazard. It's a difficult thing to do these things and that's why we need invention.

Another thing is that, when once an invention is made, it tends to be copied all over the world. So, the history of finance is largely a history of copying. That's what you have to do. You may have to adapt it to a particular environment, but basically it is copying other ideas. Some people in less-developed countries feel uncomfortable that they are just slavishly copying other, more advanced countries; but, they have to recognize that is what everybody has been doing all along. We copy the good ideas and in the process we adjust them and make them a little bit better. New ideas can come from anywhere. The basic thing, though, is that every country has to take the insights that have been developed around the world.

Let me come back now--I want to go through these three themes. Let me start with the long-term risk theme. I want to start with an article, which--mention an article by Backus, Kydland, and Kehoe--actually Backus, Kehoe, and Kydland, three economists [David K. Backus, Patrick J. Kehoe and Finn E. Kydland, "International Real Business Cycles," *Journal of Political Economy*, 100(4):745-775, August 1992]. One of these, the last of the three, Finn Kydland, won the Nobel Prize a few years ago. In this article, they talked about the correlation of consumption around the world. What is consumption? It's the amount that people spend on consumption goods, things that you buy for your current use, like food, shelter, clothing, etc. Every country computes an estimate of how much is spent each year on consumption by the people who live in the country. What Backus, Kehoe, and Kydland did was look at how much the consumption correlates--the movement from year to year--correlate across countries.

If there were perfect correlation, then it would be a correlation of one. That is, when one country's consumption increases from one year to the next, every other country's consumption increases from one year to the next. What they argued in this paper was that, if we had perfect risk management, then there would be perfect correlation of consumption across countries because if we get rid of the idiosyncratic risks, then all that's left is planet-wide risks. If we had perfect financial markets--and this is intuitive--and I don't know how obvious this is, it's obvious to me, but it's an intuitive point of great importance--nobody would suffer alone. Anytime there's a risk that hits one person or

one country the financial markets would spread it out over everybody and it gets very small. What's left? The only risks that are left are risks that everyone shares, so you would see planet-wide risks expressing themselves in consumption, but nothing else. Do you see that point? We'd have perfect correlation.

Suppose the planet were hit by a comet--this happened--something like this happened sixty-five million years ago, so it could happen again. Maybe it won't now that we have better plans to prevent things like that, but suppose it did happen. We would see huge damage on the impact site. Let's neglect the fact that some people would be killed by the impact, suppose it was just economic damage. It would be a terrible--it would be a problem all over the world because the damage would extend around the world; but, you'd be much better off if you were on the other side of the world, not where it hit. If we didn't have financial arrangements, then the people near the impact would be in a terrible economic situation and the people on the other side would be much better off.

If we had the proper risk management institutions in place, people would have anticipated this risk and would have made swaps or other arrangements to protect themselves against it. What would happen? The people near the impact would not be harmed any more than anyone else. The world would suffer because the damage is substantial and it reduces our ability to produce. So, the whole world--everyone's consumption around the world would go down. You can't prevent that. Anything that hits the whole planet would be affected. Backus, Kydland, and Kehoe thought that that's the situation we should be in today. There are things hitting the whole world, like global warming for example, and there are many of them. How well are we doing? We're not doing well at all, they concluded. The correlation across countries in consumption changes is low. In fact, it's lower than the correlation of income changes, which is surprising. It means we really haven't done anything--that's an exaggeration--we've done very little to manage risks that individuals or that countries face, for that matter, or even individuals face. We've done a lot--I shouldn't say we haven't done anything--but we can do a lot more.

The idea of risk, that economic risks can be pooled, is an intuitive one that has occurred to people throughout history. It's very simple and obvious. If we're living in--imagine we're living in some remote area and we're pioneers out there with our cabins and there's no government. There's no one to protect us. What do we instinctively do? We kind of meet together and we say, if anyone's cabin burns down we'll all come over and help. It kind of feels like generosity, but it's also a self-interest that people perceive. It could be me that--my cabin could burn down and I would freeze to death in the winter. So, people naturally and spontaneously make arrangements to share risks. These kind of natural and spontaneous arrangements are not global, they're not big enough and important enough.

I just want--one point of this lecture is to try to emphasize the real breadth of the concepts of finance and how important they are--how they reach out into other things that you might not think as associated with finance. I want to mention socialism. This term really goes back to Robert Owen, who was a British thinker from 1771 to 1858, who wanted to pool all the economic activity in society. What were the motivations for doing this? Well, I think he would say inequality--hardship would be reduced. But, what was he really saying in a sense? You might say it was risk management. He wanted society to pool risks and put things--put us together. In his ideal society--socialist society--all the

consumption would move up and down together, just as in the ideal that Backus, Kehoe, and Kydland expressed. Robert Owen wanted to create this community. He created finally--he emigrated to the United States and he set up a city called New Harmony. New Harmony was supposed to be an inspiration. Unfortunately, it didn't work very well because people started bickering in his town and the New Harmony became kind of a joke--it was not a harmonious community. So, he started to discover moral hazard. You put everyone together and you say, okay all of your economic fortunes are the same. And what does someone start to conclude? Well, they start to get lazy or they start to get irresponsible. They think, it doesn't matter what I do, I'm going to get the same consumption as everybody else, so I'll just get lazy--a very fundamental problem, which you probably are already aware of.

The socialist idea started to lead to a number of experiments in various countries around the world that were pooling risks--they might not have put it this way. One is the kibbutzim in Israel, which were communities that shared everything. Originally, they were very rigid about this. They enforced complete sharing and if you belonged to a kibbutz you were completely stuck with the common consumption. It wasn't just in Israel--in Japan, the Ito-En and Yamaguchi-kai; in the United States, the Hutterites; and there are many other examples. Joining one of these communities has meant a real change in your life. It's complete sharing.

The problem is again the ideal--they're trying to work toward what I think of an ideal that we see in finance--mainly, the perfect correlation of consumption and the elimination of risk--we all help each other. But, the problem they hit is moral hazard. I've heard a lot of stories about a lot of bickering at the kibbutz. When someone gets a gift and the other people at the kibbutz say, "Well you can't have that by yourself, we share everything." Some people say, "I'd like to have my own television set. I don't want to go to the common room and watch the same set with everyone else. I just, kind of, want to be at home by myself." So, nowadays kibbutzim have loosened the rule. I don't know these things personally, but it's my understanding that the whole structure is suffering some moral hazard problems and that they're evolving and trying to improve the institutions. There's also a problem with risk-sharing at that level. That is, if you are one of these commune communities, then you're just a small number of people. The best you can do sharing among yourselves is sharing your own risk, the risk of your own community; but your own community goes up and down and you're not sharing widely enough. The problem is that if you want to do risk-sharing, you're not, ideally, sharing with someone who's just like you--living in Israel, working in a certain agricultural industry--because there are lots of risks that you've already shared. You should be sharing your risks with someone who's completely different--probably living on the other side of the world in a completely different industry, where the weather, the institutions, and the political situation are completely different. It doesn't work so easily to share with those people along the lines that these communities--I think these communes tend to emphasize a social compact, a feeling for each other, a caring for each other, which is a lovely thought but it doesn't achieve risk management on a big scale.

I think that what's happening is these ideas--Everything is evolving, so I'm actually presenting here our modern finance as the outgrowth of socialism, but that's not the usual way to present it. I guess it is that we care about each other and we don't want people to suffer alone. We want to share things, but we want to get more scientific

about how we share things and that means--and we want to be effective. So, that means we have to devise ways of sharing with people that we've never met, that we don't care about--I mean, maybe we care about everybody, but we don't have any particular emotional ties to them--and they're very different people. But, because of the logic of risk management we have to make a deal with them; so, it becomes more formal and impersonal. That is what financial markets do.

What's happening is: we're seeing an evolution of risk management. You hear about it in various terms that sound abstract. We have private equity, we have venture capital, and we have employees getting incentive options. These are efforts to solve the moral hazard problem and to manage risks. I believe that we're gradually learning in our society. This is maybe not widely appreciated, but every decade that goes by we do a better job of incentivizing people and preventing them from being discouraged by risks. It's a very complicated situation because the kind of economic risks that we face are difficult for most people to understand. But they have to try to let people manage their own risks for themselves, to some extent. That means we have to expect people to understand these things somewhat. I think we have an important role for economic, financial education. Because of that, each person is in a different situation--it's a very complicated world and we have many different risks.

Continuing on the risk theme, I mentioned one philosopher, Robert Owen. I could have also mentioned Karl Marx--why don't I mention him here. He was a very important thinker who had very low regard for the financial community, I think, unfortunately. He wanted to kill them, I think, or at least some of them. Nonetheless, he shared certain things in common with them. Namely, that he was concerned about inequality, about some people doing badly, and he proposed an economic alternative that would pool risks. In fact, he actually emphasized a concept that was first stated by a French philosopher Louis Blanc in the mid-nineteenth century. Blanc said the ideal society is based on the principle of, and now I quote, "From each according to his abilities, to each according to his needs." Have you heard that quote before? Karl Marx quoted Blanc, but he didn't credit Blanc. He didn't mention the name because, I assume, he thought everyone knew this was Blanc; but Marx was falsely attributed to having made that statement. It's come around to us that that was--a lot of people say that was the core of his communist philosophy. That is complete risk-sharing, right? Some of us have high abilities and we succeed, some of us have low abilities and we fail; but we all get the same good, we all have our needs satisfied. So that, I think--The communist system is effectively a theory of risk management and that's not something you might think of usually.

What was the big problem with communism, as it was espoused by Karl Marx? The problem was that it had a moral hazard problem and--I've already been through it--it's the same moral hazard problem that you see at the kibbutzim and the Yamaguchi-kai and other places: that people don't work effectively when their economic interests are completely pooled. Well, I suppose we've learned from the Marx experience, but we're, I think--Just about every country of the world now recognizes that it's a complicated thing to get risk management working well and we have to design things more carefully. We can't just smash things and start all over, we have to design a system of risk management. That's what I think finance is about.

I want to mention a couple other philosophers who talk about risk management. One of them is the economist, John Harsanyi, who won the Nobel Prize in Economics

some years ago, and another one is the philosopher John Rawls, who wrote the book *Theory of Justice*, [John Rawls, *A Theory of Justice*, Cambridge MA: Belknap Press of Harvard University Press, 1971.] which has become a classic. I think of both of these as incorporating--I would, especially with Harsanyi, but also with Rawls--as incorporating some idea of risk management into our basic philosophy. We have a philosophy that--most of us--that some kind of economic inequality is a bad thing and that it's unjust for someone who is, for no fault of his or her own, suffering economic hardship. How to formalize this idea? John Harsanyi was the first to write about this. [John Harsanyi, "Cardinal Welfare, Individualistic Ethics, and Interpersonal Comparisons of Utility" *Journal of Political Economy* 63(4) 1955.] He said that we should think of--When we think about distributional justice we can think of it as a risk management problem. He said, imagine that we could get people to have a big town meeting for the whole world and, he said, before they were born. There's some space up in heaven where all the unborn babies are that will live in the future and, unfortunately, they're not able to have a town meeting; but, let's suppose they could.

We're up there in heaven thinking about our lives in the future, as people, and what would we do? Suppose we don't know what economic circumstances we'd be born into and what kind of contingencies we'd have in life. What would we decide? Suppose we were trying to decide on a constitution for the world in that state. John Rawls expanded on this and he called it the "original position." What would they do? Well, they would probably agree that we'd do some risk-sharing, right? Everyone who's thinking, I don't know whether I'll be rich or poor, so I would like to have a world in which risks are shared. On the other hand, what would you decide? If you can imagine yourself in that situation, what would you decide about inequality? Would you decide to have a world with absolute equality?

Well, you know somebody would probably. Suppose someone proposed that up in heaven and someone else might say, well that's not going to work so well, that's like a kibbutz--like one of the kibbutzim. It's not going to work, we're not going to enjoy--something's wrong with that because it's going to create a moral hazard problem and we're not going to be as productive. Someone might also say, you know a little inequality, even a substantial inequality, is not so bad as long as nobody is really suffering. As long as everyone has the basic needs and they're--we can all be happy. You know, let's let some people make big fortunes because that provides spice in life and some adventure, something to look forward to--that you might get this. You could see saying, we don't want to eliminate inequality. What Harsanyi and Rawls both gave us was a system of justice that, in my mind, conveys a sense of financial risk management. I'm not going to talk a lot about--Well, I'm going to move also to framing here, but let me at this point mention something about public finance. This is not a course in public finance. It doesn't say--The title of this course is Financial Markets. I guess when you put markets on it that doesn't sound like public finance but, even so, it could. Public finance is the financial issues relating to governments. Finance usually means the private sector, but the issues are much the same in both cases. Let me say something about public finance here. Public finance relates to the tax and welfare system that we have. The government taxes people and it takes some of the money and redistributes it to people in need. This is essentially a risk management system. It's something that, I suppose, Robert Owen and Karl Marx would have said sounds like a good thing. But, of course,

they wanted to do much more and be more comprehensive. It's maybe something that has evolved as something that actually works. You have a progressive tax system that takes more money from the wealthier people and you have a welfare system that looks at individual hardship and pays out. It does create moral hazard problems--that's a problem with it, but that's something that we're learning about. That's part of public finance--is learning how to modify the tax system so that it works pretty well.

I want to start out by mentioning taxes and welfare because, I think, that it's really the most important risk management system already in place. Because the financial risk management system that we have is imperfect, we aren't there yet. The thing that's really doing the heavy hitting on risk management is really the tax and welfare system. That's because the most important risk that individuals face is the risk of major losses of income. If something really hits you hard and you would be starving, that would be really bad. So, nobody starves in advanced countries of the world today because of this system. Moreover, you might get hit by an illness and then you could be in desperate trouble that you will die unless you get some kind of emergency care, which might be very expensive. Every advanced country in the world has a system that provides for this, including the United States, incidentally. We don't have a national healthcare system. People say we don't--well, we don't, but we do have an emergency care system so that anybody who is suddenly stricken will be taken to a hospital and taken care of. It's not perfect, but it is there. What we do have we should be thankful for, it's very important. I thought this would be a good lead in to the second theme of this lecture, which is framing. We have a good system in taxes, but it's imperfect because it hasn't been thought out thoroughly in terms of risk management. Let's talk about framing and taxes. If you go to look at congressional discussion of tax rates, you won't see risk management mentioned very often. They seem to talk about it in their own terms, which to a public finance expert is, I don't know, very populist or unprofessional. I guess they're elected officials and their voters are not finance theorists and don't think of this in these terms. Edward McCaffery did a history of taxes--I'm sorry, spelled with two Cs--he's a law professor in the United States and asked about--based on issues of framing and psychology. We have a system, which you say it really--The progressive tax system is very important but it's not conceptualized right. [Edward J. McCaffery, "Cognitive Theory and Tax," in Cass R. Sunstein, editor, *Behavioral Law & Economics*, Cambridge: Cambridge University Press, 2000 398-422.]

What McCaffery points out is that the only time the government in the United States has ever been able to impose high taxes on wealthy people was during wars. If you look at the history of U.S. taxes, the very simple history is World War One and World War Two. During World War One and Two, our men were out dying in Europe and people voted for someone who said, let's raise the taxes on the rich, someone's profiting from this war now. It doesn't sound right when other men are out there dying, so they raised taxes during World War One. They did it again, even more decisively in World War Two, and that's how we got progressive taxes. I'm oversimplifying a little bit but between wars the rate tends to come down because people think, well the war is over. They don't understand the risk management function of it. Politicians are reluctant to cut taxes, but they do it gradually. That's a simple history of taxes. Actually, in the United States, the income tax came in during the American Civil War and it was--the income tax came in 1861, again during the war and it was a progressive tax. The tax, as of 1862, was 3% on

incomes over \$600 a year. That sounds kind of low, that was 1862. Then they raised it to 5% on incomes over \$10,000. It was a beginning, but it didn't take because they had technical problems.

I mention this tax example because I want to stress that framing and psychological barriers are important problems for creating financial markets. The idea is that people don't see this basic risk management problem and they see things in entirely different terms. So Kahneman and Tversky talked about how people view financial gains and losses and they talked about how people's actions are very valuable depending on how things are presented. In one of their most famous examples, they asked people the following question:

Suppose you had bought expensive tickets to a concert, very expensive, you paid \$200 for each ticket. You have two tickets, \$400 worth, and on the way to the concert you lose the tickets. Now, you've arrived at the concert hall and you're looking through your pocket and you realize they're gone--you've lost them. The question they asked people is: would you go to the window and buy another pair of tickets for \$400, having lost them?

People answered--most people said, no, I'd be so annoyed and angry with myself I'd just leave. But then they posed a different version of the same question and the different version was:

Suppose you had ordered tickets to pick them up and pay for them at the window at the concert hall and you brought \$400 in cash in your pocket. You arrive and you realize you've lost your \$400. Now, the choice is: you could--What are you going to do? Would you go to the ticket window and use your credit card to pick up the tickets or would you just walk away in anger and annoyance?

Well, most people say, oh I would just go to the window and buy the tickets. Does that sound plausible that you could see the difference? But, in economic terms, there's no difference between losing the tickets and losing \$400, so why do you behave differently? Well, that's framing. Because in your mind you're putting tickets and cash in different mental accounts, the mental account "tickets" generates an emotional feeling and it changes my action--that I lost in that account. Unfortunately, that's--unfortunately people's decisions are biased by that kind of thing. So, we have to frame things as--put things in the mental categories--presentation matters--so that people can manage their risks right.

Kahneman and Tversky also--and others have also talked about insurance. They've asked people a question and then phrased it in two different ways. One of them was, would you buy insurance against such and such a risk? The same question was rephrased in another way, without mentioning the word insurance--they just described it. They said, would you sign a contract that if you had this loss the contract would pay you a certain amount of money? The percent of people who said yes to that was lower because they didn't put it in an insurance frame. We are accustomed to thinking of insurance as a good thing. If I talk about it in general terms, they might not put it in that frame and they might not--

Really, an important example of framing is how we deal with money and indexation. We have a "money frame" of thinking and a "real frame." The value of money changes through time because of inflation or deflation; yet, most of our debts are written in money terms. That is, they're not indexed for inflation. If you wanted to have a real frame,

then you would index to the consumer price index or some other inflation index. Most of us are accustomed to a money frame, so most of us--when we lend money to each other, we do it in money terms. You merely say--For example, if your friend asked to borrow \$100 from you, you would probably not say--you might actually put interest on this person, so you could say, alright, I'll do it with 5% interest, pay me back in a year. You would probably not even think to say, pay me 3% interest plus the rate of inflation over the next year. That would be putting it in a real frame and--wouldn't that be more sensible, because you would be specifying the contract in real terms rather than money terms? Yet, most people just don't do that. Most of our fixed incomes, as they're called--which are assets that are denominated in currency--Most of our debts are written in money terms and people can't get over this framing in terms of money. It's a powerful psychological, you might say, illusion--people think they want money when, in fact, they should want real goods and services. So, that's an example of a framing issue.

Now, I want to move to the third theme of this lecture, which is invention. As I said, progress in finance requires an inventive process and invention occurs in a milieu of other invention, notably information technology. I said this is an earlier lecture, but a financial device is a complicated device like any engine or any other thing that they patent and develop to solve some physical problem. For example, let's talk about an insurance policy as an invention. An insurance policy--the concept is very simple, we could talk about fire insurance or life insurance. Life insurance is designed to protect--ideally, it protects parents with young children--that's the most important application. If one of the parents dies, it creates hardship for the family because the remaining parent has the burden of caring for children and earning a livelihood to support all of them. It is very difficult, so we have a policy that pays them if one of them dies.

It's not easy to devise this and the concept is very simple. In order to devise an insurance contract that does this job, we have to have a contract between an insurance company and the insured. The contract has to specify what are the causes of, let's say, death or a situation in which one is covered. We have to then realize that there is a moral hazard problem. We have to exclude certain causes, like suicide, in the case of life insurance. In other kinds of insurance it gets very complicated. You have to exclude those causes that generate moral hazard problems for the insurance to work; otherwise, the whole system will fail. When they invented fire insurance, in the 1600s, there was a lot of skepticism because anyone can burn down their house. They said, it's not going to work because you have to decide how much the house is insured for and then anybody--If you ever make a mistake and you insure it for too much, then the people who realize they've got one on the insurance company--they've insured the house for more than it's worth--they'll burn down their house and collect the money.

Now, how can the insurance company ever evaluate every house properly to avoid that? They had to work on that, they had to devise--they had to get an appraisal industry that could appraise houses and get some idea of what they're really worth. They had to get that all worked out, it had to be done accurately, and they had to decide to keep a certain amount of co-insurance. In other words, lower the amount insured below the actual value of the house to prevent moral hazard. They had to develop statistics of loss; they had to know what the losses were. In the case of life insurance, they developed actuarial tables that require a collecting of statistics.

Then of course, there's the other problem that the insurance company--how does the

insurance company reasonably specify that it can come through on this policy? You have to have the insurance company set up with a structure itself that guarantees that they have enough reserves to meet the losses that they might incur. That requires a theory of capital and they're going to have to invest the reserves in financial assets. Then you have to ask, well how are the financial assets going to behave over time? Then it becomes a theory of--all of finance comes in as well.

Moreover, beyond that, how does one know, in taking out an insurance policy, that the insurance company is going to be sound? The insurance company has to have some way of demonstrating its soundness to the public. Moreover, we have regulators who have to regulate insurance companies and make sure that they have adequate capital. So, it's a very complicated industry. Although, I said, insurance was effectively discovered or invented in the 1600s, it has been slow to grow because they didn't have the well-defined--all of the inventions yet. I wanted to just give some--often the inventions that occur in finance, they seem in a way obvious. Some of the things I said--you'd probably say, well I should have known that an insurance company would have to do that, but it isn't. What's obvious after the fact is not what's obvious before the fact.

One thing I'd like to stress is that the history of technology is sometimes a history of very glamorous, unobvious ideas like nuclear power. That's amazing, you can get atoms to smash atoms and create a chain reaction and create power--that's a pretty amazing invention. But a lot of the inventions that matter to us are extremely simple. They're kind of staring in your face obvious. Let me just give some example of--sometimes people are very slow to see the obvious, or it seems so in history. I'd like to talk about the invention of the wheel--that's the most famous invention, right? It's a cliché--People say, let's not reinvent the wheel here, so let's go back to that. Inventing the wheel--it seems, what could be more obvious than a wheel? Well, it apparently is not so obvious because in the Americas, before Columbus came--pre-Columbian America--there were no wheeled vehicles anywhere. We had civilizations--Aztecs, Mayas, Incas, etc.--but no wheeled vehicles. Now, the amazing thing is, if you go to Mexico you can go to museums that have children's toys from pre-Columbian Mexico with wheels. They were little toys that--they would be shaped like animals or something and you could roll them along the floor. So, why didn't somebody think of--you're sitting there with your child playing with a wheeled toy and then you're going out to carry some heavy stuff and you're dragging it along the ground. Why didn't you think of putting wheels under it? Well, it's apparently not so obvious.

Some very obvious ideas are not so obvious. Some people today think, I just can't imagine, this history can't be right, I don't believe that they hadn't invented wheels in America before Columbus. To argue with them, I point out an example, which is more familiar. Unfortunately, you people are too young to have experienced this, but I've experienced this and you can talk to your parents. It used to be, before 1972, that suitcases never had wheels. You probably own a wheeled suitcase, right? Most of you do. The idea of putting wheels on suitcases goes back only to 1972 and it was Bernard Sadow who invented--this is amazing, right--the wheeled suitcase and he got a patent on it. He had a suitcase that--I don't know exactly, something like this--had a strap that you'd pull it along and it had four little wheels on the bottom and it worked.

I had my student research assistant find that guy, let's call him up and ask him about it. It's so recent. So my student called Bernard Sadow up and asked him about his invention

and he said, "Yeah, I was thinking, why don't we have wheels on suitcases? So I just did it." He said, "I had a lot of trouble, I took it to department stores and I said, why don't you sell this? I'm making it, add it to your luggage." He said he met a lot of resistance. The department stores said no and so we asked, why would they say no? I mean, it's such an obviously good idea. He said, "They said people won't buy it. Anyway, they said, look you go to any train station and there are these red caps or porters and they'll carry your suitcase for you. You don't need wheels." That's what they told him. But, it seemed like there was kind of a way of thinking. I think maybe people would be embarrassed. If you were the only guy with wheels on your suitcase, people would think you look a little odd. Anyway, it's interesting the wheeled suitcase came in 1972.

The problem with Sadow's suitcase--I actually had one and you might have one in your attic. You can go up and look at it because your parents probably bought one and it's still up there. You can take it out and try wheeling it along with that strap. It kind of works, but it wobbles, especially if you're hurrying to catch your airplane. That thing starts fish-tailing and wobbling. You've just got a strap you're pulling it on--so obviously there was a design defect. Finally, it was Robert Plath, who was an airline pilot who invented a new, wheeled suitcase, which he patented in 1991. This suitcase had--instead of having four little wheels on the bottom, it had two wheels on the back. You didn't pull the suitcase lengthwise; you pulled it widthwise, so it gave you a stable base. Moreover, instead of having a strap he had this thing that--a rigid thing--that you pull out from this--you know what I'm talking about? He invented--he called it the RollAboard. He also had the idea that he would make it narrow enough so that when you're boarding an airplane you can still roll it down the aisle of the airplane--it just fit perfectly. So, that was the RollAboard--that was 1991. That's getting into recent memory. It's so obvious, why didn't they have them before? Well, things that seem obvious are not obvious and it has something to do with--something like framing. We tend to think of doing things in a certain way--everyone else is doing it--and we assume that that's the smart way to do things. That limits us and it's very hard to get new ideas started, but they do get started; so, I think we'll get some really obvious advances.

One thing about inventions is that we have something called patents. The patent office grants patent rights to inventions, but traditionally in--everywhere in the world, really, financial inventions were not considered worthy of patenting because, I guess, patent law came in response to things like the steam engine and the power loom, which were physical inventions. They didn't think of financial inventions as worthy of patents. Now, we're starting to see patent offices accepting financial devices. It happened in the late 1990s, in the United States, that patent offices started to accept financial patents. Now there are several countries that--Japan, Korea, and elsewhere--are starting to see financial invention as a serious invention.

The last thing is information technology, as a driver of finance. Now, I'd like to stress information technology because we are living in a time of rapid advance, as you know--I don't have to tell you this. Computers are becoming more and more a part of our lives and this is something that is transforming the world. What is it that makes us uniquely human? You might say--or a good part of--it is our ability to process information. We differ from lower animals and our brains, which are much more capable of storing and processing information, but we're living in a time of revolution when machines are challenging or competing with our brains. This may create economic dislocations that

we will see throughout our lives, but also creates opportunities--I want to stress on the opportunities. A lot of financial innovation is co-evolved with information technology. A lot of simple ideas of risk management are ideas that require well-designed information technology and we've seen a lot of advances in the last couple centuries that make financial innovation possible.

I thought I would give you an example from the nineteenth century, which is very important, and again it's public finance. I'm not going to stress public finance so much in this course but it seems--I'm going to give the example of nineteenth century information technology and the nineteenth century invention of social security. Let's go back to the nineteenth century, that's the 1800s, that was a wonderful century for information technology. You probably don't think of it that way because you say, wait a minute, the computer wasn't invented until the 1940s. Actually, you would be wrong; the computer was invented in the nineteenth century by Babbage, but he didn't actually make one. He wrote down a design, which was similar to what we do now.

There were a lot of other things that happened in the nineteenth century that advanced information technology and made finance really powerful. One was paper, it sounds very simple. At the beginning of the nineteenth century, in 1800, paper was handmade out of cloth--that's the way they made it. Paper, therefore, was very expensive. So, if you bought a newspaper it would be only two sheets because it was so expensive--not all the thick paper that we have today--and it would cost something like \$10 or \$20 in today's prices. It would only be wealthy people who would buy that everyday. They invented the paper machine so they could mass-produce paper--it didn't have to be handmade anymore--and they invented wood pulp paper so it didn't have to be made out of cloth anymore. The price of paper fell and created opportunity for record-keeping, which was very important because that's what finance is built--you need financial records. You can't have just one copy; you have to have multiple copies.

They also invented carbon paper. Maybe you don't even know what this--do you all know what carbon paper--I guess you do know what this is, right? It's obsolete. Do you have any carbon paper anyone, here in your room? You do? Okay, so it's not obsolete. Anyway, it's just paper with some black material on it. You put it between two pieces of paper, then you write on the top one and it creates a copy on the bottom one. You can make multiple--you can put three or four--the copy gets worse and worse each time, but you've got multiple copies. That's information technology. You really need that because if you have only one copy of something, you don't have a backup; so, you can store the one copy separately.

Also, in the nineteenth century, the typewriter was invented. Of course, that may be the core idea of a computer. Your computer looks like a typewriter, but a typewriter just speeds recording of information. Tests show in the nineteenth century that people could type four or five times as fast as they could handwrite and there's no ambiguity because it's very clear what key was struck; whereas, handwritten--fast handwriting becomes impossible to read--or difficult.

Another thing that happened--they started developing--it's not invented in the nineteenth century, but they started doing standardized forms. That is, there would be a printed form on paper with spaces to fill in the numbers or other things. That put us at, sort of, organization on the data entry that was unknown. You have this standardized form and you've got carbon paper between them and you typed it--all these really created much

more accurate techniques.

We also got better bureaucracy. That means, we started to learn management science in the government, so that government--and also in corporations--so they could manage effectively. In the United States, we developed the Civil Service. It used to be that government officials were all picked by political patronage and they, very often, were incompetent. We set up--this is not a new idea, this goes back to China thousands of years ago, but it started to be widely done--a Civil Service exam that established your competence. So, you had competent people with their typewriters and carbon papers. Also, the filing cabinet--that sounds like a minor thing--was invented in the 1890s. Before that, people used to put papers in piles, tie them up in ribbons, and put them on bookshelves or in drawers. The filing cabinet was much more orderly and effective. So, all those things developed in the nineteenth century. It just created a new world for financial opportunity. Things started to happen in response to this and risk management got better.

I want to talk about Social Security as a risk management technique that developed in the nineteenth century and it developed in Germany. It is very interesting to me because it's a discrete invention that happened in a point of time in response to information technology. This is 1889, under the government of Otto von Bismarck--although, he has nothing to do with this, it was other people--economists in Germany that invented this idea. What did they do?

I should have also mentioned another really important information technology that developed in the nineteenth century was the Postal Service, although we had mail before then. In the nineteenth century they decided--it just got really good at delivering mail. In 1799, it would cost so much to mail a letter--I don't know exactly, something like \$10 or \$20 to mail a letter at today's rate--and it would take a long time get there. For most people it was prohibitively--we're talking in today's prices, roughly speaking. Most people wouldn't ever mail a letter or get a letter--too expensive, not to count only the paper and everything was expensive. In the nineteenth century, they developed the Postal Service and it interacted with the railroad. They started having mail cars on trains and they started having postal sorting on the train. They were speeding the mail so that it didn't have to wait to sort it before it went on the train--it was sorted while it was moving on the train. Germany was very effective in these--they had advanced bureaucracy, a good postal service, and they had a network of post offices all over the country--every little town had a post office. So, this was the internet of the nineteenth century and it really changed everything.

In 1889, the German Government decided to use the postal service as an information network to create Social Security. They created a new law, which said that every person who works in Germany has to pay the government a certain percent of his income, into the Social Security system. In addition, the employer has to match this so that both the employer and the employee have to do it. Now, how in the world can somebody actually make that work for a whole country? There were eleven million workers in Germany at the time and other countries looked on this as, this is ridiculous, no government can actually manage the system like this. But, they did it through the postal system. You had to make--or your employer can do it for you--they take the money to the post office and the post office would give you stamps. It was already the same technology they used for the mail. You kept your Social Security card and you pasted stamps on it that proved

that you paid it. They kept a copy of that and they filed it away, so the government had a complete record of your payments into the system.

The design was that, when you reached retirement age, you would then get funds from the government for the rest of your life--your retirement funds. How did they decide how much? Well, it was based on what you contributed. They would pull out your entire life history of contributions--they had it because you had filed it all at the post office and everything was bureaucratic and efficient--and they calculated, according to a formula, what you would get. It was a real insurance system and they would pay you in your retirement. The London Times, in 1889, said this is going to be a fiasco, there are going to be so many mistakes, and there are going to be so many complaints that this whole system is going to crumble and fall; but it didn't, it actually worked. Before long, the U.K. copied it.

The U.S. was practically the last country to copy this system because, in the 1930s, it didn't sound American. We were kind of reluctant to take on ideas from Germany, of all places, but we finally did. We did that during the Great Depression, when it suddenly seemed like we really needed to do something. That's an example; you see how information technology created a Social Security system. Now, the really fascinating thing is that we have the same system today, except we don't use the postal service as the conduit anymore. Now it's all electronic and it's done by the Internet, but it's the same thing. You will see, deducted from your paycheck--and you already have seen this--it says FICA and then there's a certain amount, a certain percentage of your paycheck, and the employer matches just like in Germany in 1889. When you retire--you can actually get it now, electronically, your entire employment history, all your contributions--when you retire, there will be a formula--you can find it on the Social Security system website--which resembles the formula that they did in 1889. We're still doing the same thing now. This invention of social security is well over one hundred years old, but I think that, because of the rapid advance of information technology, we're going to see a lot more progress. Over your lifetime, there are going to be a lot more inventions like this. So, that's why I think finance will be an interesting field for those of you who choose to go into it.

Finally, I just want to say, next lecture is January twenty-eighth and we're going to talk about portfolio diversification, which is one very important application of the fundamental principle of risk management, as applied to securities. It's more narrow than my very broad discussion. It's not public finance, it's not insurance, but it's one of the most important fundamental theories that underlies finance. Then you have a problem set, which is due on that day, your first problem set, and the problem set is up on the website. If you go to ClassesV2 and you click on "Problem Sets," it's Problem Set #1. We're also going to--I'm going to email you about review sections. Our first review section will be in the week of January--with your teaching fellows--will be in the week of January twenty-eighth and we're going to have to ask you to sign up with one of the teaching fellows. We'll give you times and dates when the sections occur. I'll see you on January 28.

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